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Structures Technical Memorandum 406

COMPUTED STRESS AND STRAIN DISTRIBUTIONS UNDER
INTERFERENCE FIT AND AFTER COLDWORKING (U)

by

R.P. Carey

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INTERFERENCE FIT AND AFTER COLDWORKING (U)**

by

R.P. Carey

SUMMARY

Stress and strain distributions are computed by finite element method for various levels of interference fit and for the unloaded, or coldworked condition. The assumed material properties represent a steel pin interacting with an aluminium alloy plate.



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1. INTRODUCTION

Various processes for improving the fatigue performance of bolted joints are receiving wide application in aircraft structures - especially techniques involving the coldworking of holes and the use of interference fit fasteners. It is desirable to establish procedures for estimating such fundamentals as stress and strain field, which are likely to affect the fatigue - improvement process. Some estimates for stress etc. for typical examples would also be useful.

This paper provides two-dimensional reference material on the stress and strain states for interference levels from 2% to 5% and for the coldworked state after removal of the interference. Both plane stress and plane strain data are presented.

2. ANALYTICAL PROGRAM

The F.E.M. computations are based on the interference-fittings of a high-strength steel pin in a circular aluminium alloy plate ten times the diameter of the pin. The assumed material properties of the pin and the plate are given in Table 1, whilst the assumed bi-linear stress/strain characteristics for the plate material are depicted in Fig.1 with isotropic strain-hardening assumed. Because of the much higher yield point for the pin material no allowance is necessary for yielding of the pin. Interference levels of 2%, 3%, 4%, and 5% were treated. Both plane stress and plane strain states for pin and plate were evaluated at each interference level.

The F.E.M. mesh for the pin was an 18-degree sector as shown in Figs. 2(a) and 2(b) containing 16 six-noded isoparametric triangular elements and 52 eight-noded isoparametric quadrilateral elements. Fig.2(a) also shows a plate mesh containing 116 isoparametric quadrilateral elements which was used in conjunction with the pin mesh in basic interaction computations. This combination was always used in the first instance to determine the correct relative behaviour of pin and plate although in later work the simplified plate mesh shown in Fig.2(c) was adopted to reduce the computational effort during unloading. This mesh had 76 eight-noded isoparametric quadrilateral elements dividing a 4.5 degree sector into two parts.

The interference loading was induced by specifying a relative displacement between pin and plate nodes along the interface, according to a method described in Ref.1. Unloading was arranged by reducing the relative displacement until the contact pressure became zero. The above method however was particularly demanding on computing effort at higher levels of coldworking so some cases were reworked using pressure loading and a simpler mesh once the appropriate interface pressure had been found from the interaction computations. The equality of the two methods has been demonstrated in Ref.1 and the data which was obtained by the pressure method is noted in the tables.

The analysis used the PAFEC finite element scheme (Level 5) on the A.R.L. ELXSI computer. The plasticity routines of that scheme are based on Prandtl-Reuss equations in association with von Mises' yield criterion. Modifications developed at A.R.L. were used to assist convergence.

3. RESULTS

The analysis provided stress and strain distributions along radial traverses of the plate and this information is presented in graphical and tabular form as follows:

Figs. 3(a) & 3 (b) show circumferential and radial stresses at interference levels of 2%, 3%, 4%, and 5% for plane stress and plane strain states respectively whilst Figs. 4(a) & 4(b) show the corresponding coldworked, i.e. unloaded, distributions. Thickness direction stresses for the plane strain state are given in Figs. 5(a) & 5(b) under interference and after unloading. Circumferential and radial strains for the various interference levels are illustrated in Figs. 6(a) & 6(b) for plane stress and plane strain state respectively, and the corresponding strains after unloading appear in Figs. 7(a) & 7(b). Thickness direction strains from plane stress computations are given in Figs. 8(a) & 8(b) for interference and coldworking respectively.

In addition, radial displacements and thickness changes for the plate at the interface are listed in Table 10.

4. DISCUSSION

1. Under plane stress conditions, with increasing interference level, Fig 3(a), the circumferential stress distribution patterns close to the hole changes. There is a levelling-off near the interface, and at 5% interference, there is even a reversal of slope. As the effect is not present under plane strain conditions it could be connected with the plane stress restriction which permits only two principal stresses to vary.
2. Radial stress levels are more severe under plane strain conditions than under plane stress, whilst the radial strains are more severe under plane stress. Such effects are, of course, expected in view of the fundamentally stiffer nature of the plane strain condition due to restriction on plastic flow in the thickness direction.
3. The stress and strain distributions given in this paper will provide a valuable basis for comparison with results from proposed three-dimensional investigations.

ACKNOWLEDGEMENT

The advice given by Dr G.S. Jost is gratefully acknowledged.

REFERENCE

1. Carey, R.P. and Hoskin, B.C. A finite element procedure for interference-fit and cold-working problems with limited yielding. Dept. Defence, Aeronaut. Res. Labs, Structures Report 425, Dec. 1986.

TABLE 1: Assumed Material Properties

Property	Plate	Pin
Modulus of Elasticity (MPa)	69000	209000
Poisson's Ratio	0.33	0.30
Yield Point (MPa)	480	1720
Strain Hardening Slope (MPa)	1200	486

TABLE 2. Stress and Strain Distributions versus Radial Position
- at 2% Interference and after Unloading-Plane Stress.
(see note 2)

RADIAL POSITN (1)	STRESSES (MPa)				STRAINS (x10-3)					
	LOADED		UNLOADED		LOADED			UNLOADED		
	CIRC.	RAD.	CIRC.	RAD.	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE
1.000	-47.1	-535.4	-511.9	-6	18.3	-33.3	12.1	7.8	-22.8	12.4
1.014	-38.4	-529.4	-513.3	-8.8	17.6	-31.6	11.2	7.4	-21.4	11.5
1.029	-29.2	-523.1	-518.1	-16.8	16.9	-29.9	10.3	7.0	-20.1	10.5
1.043	-18.2	-516.0	-512.6	-23.5	16.2	-28.3	9.5	6.6	-18.8	9.5
1.058	-7.6	-509.1	-500.5	-30.4	15.6	-26.8	8.6	6.3	-17.6	8.7
1.072	2.8	-502.2	-474.0	-36.3	15.1	-25.5	8.0	6.0	-16.5	8.0
1.087	12.3	-495.0	-451.6	-41.9	14.5	-24.2	7.3	5.7	-15.5	7.4
1.101	20.8	-488.7	-431.4	-47.3	14.0	-23.1	6.8	5.4	-14.6	6.8
1.116	29.7	-482.5	-410.5	-53.0	13.5	-22.0	6.2	5.1	-13.7	6.3
1.139	43.3	-471.4	-379.8	-59.2	12.8	-20.5	5.5	4.8	-12.5	5.6
1.163	57.4	-460.8	-348.6	-65.6	12.2	-18.9	4.8	4.4	-11.3	4.9
1.192	74.2	-448.2	-313.0	-71.7	11.4	-17.4	4.1	4.1	-10.1	4.2
1.221	90.9	-435.4	-277.8	-77.6	10.7	-15.9	3.5	3.7	-9.0	3.5
1.250	106.6	-423.2	-245.9	-81.5	10.2	-14.7	3.0	3.5	-8.1	3.1
1.279	122.4	-410.9	-213.9	-85.4	9.6	-13.5	2.5	3.2	-7.2	2.6
1.314	139.8	-396.6	-179.7	-87.9	9.0	-12.4	2.1	2.9	-6.4	2.2
1.349	157.3	-382.3	-145.4	-90.4	8.4	-11.2	1.7	2.7	-5.6	1.7
1.395	178.2	-364.2	-105.8	-91.0	7.8	-10.0	1.2	2.4	-4.8	1.3
1.442	199.1	-346.1	-66.2	-91.6	7.2	-8.9	.9	2.2	-3.9	1.0
1.500	221.8	-324.9	-24.8	-89.1	6.7	-7.8	.6	2.0	-3.2	.7
1.558	244.6	-303.7	16.7	-86.5	6.1	-6.7	.3	1.8	-2.5	.3
1.617	262.7	-284.1	49.7	-81.8	5.7	-5.9	.1	1.7	-2.0	.2
1.675	279.9	-264.2	81.8	-76.9	5.3	-5.1	-.1	1.5	-1.5	-.0
1.733	262.2	-247.0	76.1	-71.7	4.9	-4.8	-.1	1.4	-1.4	-.0
1.791	245.2	-229.9	71.2	-66.8	4.6	-4.5	-.1	1.4	-1.3	-.0
1.849	231.1	-215.9	67.1	-62.7	4.3	-4.2	-.1	1.3	-1.2	-.0
1.908	217.1	-201.9	63.0	-58.6	4.1	-3.9	-.1	1.2	-1.2	-.0
1.966	205.4	-190.2	59.7	-55.2	3.8	-3.7	-.1	1.1	-1.1	-.0
2.024	193.7	-178.5	56.3	-51.8	3.6	-3.5	-.1	1.1	-1.0	-.0
2.082	183.9	-168.7	53.4	-49.0	3.4	-3.3	-.1	1.0	-1.0	-.0
2.141	174.1	-158.8	50.6	-46.1	3.2	-3.1	-.1	1.0	-.9	-.0
2.199	165.7	-150.5	48.1	-43.7	3.1	-2.9	-.1	.9	-.9	-.0
2.257	157.4	-142.1	45.7	-41.3	2.9	-2.8	-.1	.9	-.8	-.0
2.315	150.2	-134.9	43.6	-37.2	2.8	-2.6	-.1	.8	-.8	-.0
2.373	143.0	-127.8	41.5	-37.1	2.6	-2.5	-.1	.8	-.7	-.0
2.432	136.9	-121.6	39.8	-35.3	2.5	-2.4	-.1	.7	-.7	-.0
2.490	130.7	-115.4	38.0	-33.5	2.4	-2.3	-.1	.7	-.7	-.0
2.548	125.3	-110.1	36.4	-32.0	2.3	-2.2	-.1	.7	-.6	-.0
2.606	119.9	-104.7	34.8	-30.4	2.2	-2.1	-.1	.7	-.6	-.0
2.664	115.3	-100.0	33.5	-29.0	2.1	-2.0	-.1	.6	-.6	-.0
2.723	110.5	-95.2	32.1	-27.7	2.0	-1.9	-.1	.6	-.6	-.0
2.810	104.4	-89.2	30.3	-25.9	1.9	-1.8	-.1	.6	-.5	-.0
2.897	98.2	-83.0	28.5	-24.1	1.8	-1.7	-.1	.5	-.5	-.0
3.072	88.8	-73.6	25.8	-21.4	1.6	-1.5	-.1	.5	-.4	-.0

1. Radial distance from hole centre is expressed non-dimensionally as a ratio to hole radius.
2. Quoted values are from displacement loading on Fig. 2 (a) mesh.

TABLE 3. Stress and Strain Distributions versus Radial Position
- at 3% Interference and after Unloading - Plane Stress.
(see note 2).

RADIAL POSITN (1)	STRESSES (MPa)				STRAINS ($\times 10^{-3}$)					
	LOADED		UNLOADED		LOADED			UNLOADED		
	CIRC.	RAD.	CIRC.	RAD.	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE
1.000	-129.4	-600.0	-543.6	.2	27.4	-61.4	30.4	15.3	-49.4	31.4
1.015	-123.7	-593.3	-545.5	-7.6	26.1	-57.6	27.9	14.4	-45.9	28.8
1.030	-117.8	-586.6	-546.8	-15.5	24.9	-53.8	24.9	13.6	-42.4	26.1
1.044	-110.1	-579.9	-545.0	-23.0	23.9	-50.5	23.2	12.8	-39.5	23.9
1.059	-102.7	-573.4	-543.1	-30.5	22.8	-47.3	21.1	12.1	-36.6	21.7
1.074	-94.	-566.8	-543.0	-37.2	21.9	-44.5	19.4	11.5	-34.1	19.8
1.089	-85.2	-560.2	-542.7	-44.1	21.0	-41.8	17.6	10.8	-31.7	17.9
1.103	-76.4	-554.0	-542.2	-50.8	20.2	-39.5	16.2	10.3	-29.7	16.5
1.118	-67.0	-547.5	-541.2	-57.3	19.4	-37.2	14.8	9.8	-27.7	14.9
1.133	-57.5	-541.2	-536.7	-63.5	18.7	-35.3	13.6	9.3	-26.0	13.7
1.148	-48.1	-535.0	-529.7	-69.7	18.0	-33.3	12.4	8.9	-24.3	12.5
1.162	-38.6	-528.8	-504.5	-75.2	17.4	-31.7	11.5	8.5	-22.9	11.5
1.177	-29.0	-522.5	-483.3	-80.7	16.8	-30.0	10.5	8.1	-21.4	10.6
1.194	-17.7	-515.2	-459.0	-86.2	16.1	-28.3	9.6	7.6	-20.0	9.6
1.212	-6.3	-507.8	-434.7	-91.7	15.4	-26.6	8.7	7.2	-18.6	8.7
1.230	4.8	-500.5	-411.8	-96.3	14.9	-25.2	7.9	6.9	-17.4	8.0
1.248	15.8	-493.2	-389.1	-100.9	14.3	-23.8	7.2	6.5	-16.2	7.2
1.266	26.5	-486.1	-367.5	-104.5	13.8	-22.6	6.6	6.2	-15.2	6.6
1.283	37.2	-478.9	-346.0	-108.1	13.3	-21.4	6.0	5.9	-14.2	6.0
1.300	47.4	-471.8	-325.8	-111.1	12.8	-20.4	5.5	5.7	-13.4	5.5
1.319	57.6	-464.8	-305.6	-114.1	12.4	-19.3	5.0	5.4	-12.5	5.0
1.336	67.4	-457.8	-286.5	-116.3	12.0	-18.5	4.6	5.2	-11.8	4.6
1.354	77.2	-450.9	-267.5	-118.4	11.6	-17.6	4.2	5.0	-11.1	4.2
1.372	86.6	-444.0	-249.7	-120.2	11.2	-16.8	3.8	4.8	-10.5	3.9
1.390	96.0	-437.2	-231.7	-121.9	10.8	-16.0	3.5	4.6	-9.9	3.5
1.410	106.4	-429.3	-212.1	-123.2	10.5	-15.2	3.2	4.4	-9.2	3.2
1.431	116.5	-421.6	-192.6	-124.5	10.1	-14.4	2.8	4.2	-8.6	2.9
1.451	126.7	-413.8	-194.3	-125.2	9.8	-13.7	2.6	4.0	-8.1	2.6
1.472	136.5	-406.1	-156.1	-125.9	9.4	-13.0	2.3	3.8	-7.6	2.3
1.493	145.8	-398.6	-139.1	-126.1	9.1	-12.9	2.1	3.7	-7.1	2.1
1.513	155.1	-391.1	-122.1	-126.4	8.8	-11.8	1.8	3.5	-6.7	1.9
1.534	164.0	-383.7	-106.1	-126.0	8.6	-11.3	1.7	3.4	-6.3	1.7
1.555	172.8	-376.3	-90.2	-125.8	8.3	-10.8	1.5	3.3	-5.9	1.5
1.575	181.2	-369.1	-75.3	-125.1	8.0	-10.3	1.3	3.2	-5.5	1.4
1.596	189.3	-361.9	-60.3	-124.4	7.8	-9.8	1.2	3.0	-5.2	1.2
1.617	197.4	-354.9	-46.4	-123.5	7.6	-9.4	1.0	2.9	-4.9	1.1
1.637	205.4	-347.8	-32.3	-122.5	7.4	-9.0	.9	2.8	-4.6	1.0
1.658	212.7	-340.8	-19.4	-121.1	7.2	-8.6	.8	2.8	-4.3	.8
1.679	220.0	-333.8	-6.5	-119.8	7.0	-8.2	.7	2.7	-4.0	.7
1.708	230.4	-324.3	11.2	-117.7	6.7	-7.7	.5	2.6	-3.7	.6
1.738	240.7	-314.8	28.9	-115.5	6.5	-7.2	.4	2.5	-3.3	.5
1.767	250.0	-305.5	44.8	-112.9	6.3	-6.8	.3	2.4	-3.0	.3
1.797	259.3	-296.2	60.7	-110.2	6.0	-6.4	.2	2.3	-2.8	.2
1.826	268.0	-287.3	75.5	-107.3	5.9	-6.0	.1	2.2	-2.5	.1
1.856	280.1	-278.2	93.6	-104.3	5.7	-5.6	-.0	2.1	-2.2	.0
1.900	280.0	-265.4	101.6	-99.6	5.4	-5.3	-.1	2.0	-2.0	-.0
1.944	274.6	-252.7	104.2	-95.0	5.2	-4.9	-.1	1.9	-1.8	-.0
1.989	261.4	-241.5	98.0	-90.6	4.9	-4.8	-.1	1.9	-1.8	-.0
2.033	250.2	-230.2	93.8	-86.4	4.7	-4.5	-.1	1.8	-1.7	-.0
2.092	237.3	-217.4	89.0	-81.6	4.5	-4.3	-.1	1.7	-1.6	-.0

Table 3 : Continued

RADIAL POSITN (1)	STRESSES (MPa)				STRAINS ($\times 10^{-3}$)					
	LOADED		UNLOADED		LOADED			UNLOADED		
	CIRC.	RAD.	CIRC.	RAD.	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE
2.151	224.5	-204.5	84.2	-76.7	4.2	-4.0	-.1	1.6	-1.5	-.0
2.210	213.6	-193.7	80.1	-72.7	4.0	-3.8	-.1	1.5	-1.4	-.0
2.269	202.8	-182.9	76.0	-68.6	3.8	-3.6	-.1	1.4	-1.4	-.0
2.328	193.5	-173.6	72.5	-65.1	3.6	-3.4	-.1	1.4	-1.3	-.0
2.387	184.2	-164.3	69.1	-61.6	3.5	-3.3	-.1	1.3	-1.2	-.0
2.446	176.2	-156.3	66.0	-58.6	3.3	-3.1	-.1	1.2	-1.2	-.0
2.505	168.2	-148.3	63.0	-55.7	3.1	-3.0	-.1	1.2	-1.1	-.0
2.564	161.2	-141.3	60.4	-53.0	3.0	-2.8	-.1	1.1	-1.1	-.0
2.623	154.2	-134.3	57.8	-50.4	2.9	-2.7	-.1	1.1	-1.0	-.0
2.711	145.3	-125.4	54.5	-47.1	2.7	-2.5	-.1	1.0	-.9	-.0
2.800	136.2	-116.2	51.0	-43.6	2.5	-2.3	-.1	.9	-.9	-.0
2.977	122.5	-102.6	45.9	-38.5	2.3	-2.1	-.1	.9	-.8	-.0

1. Radial distance from hole centre is expressed non-dimensionally as a ratio to hole radius.
2. Quoted values are from pre-determined pressure loading on Fig. 2(c) mesh.

TABLE 4. Stress and Strain Distributions versus Radial Position
- 4% Interference and after Unloading - Plane Stress
(see note 2.)

RADIAL POSITN (1)	STRESSES (MPa)				STRAINS ($\times 10^{-3}$)					
	LOADED		UNLOADED		LOADED			UNLOADED		
	CIRC.	RAD.	CIRC.	RAD.	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE
1.000	-139.9	-641.5	-584.4	.2	36.9	-91.9	51.2	23.9	-79.0	52.3
1.015	-139.6	-634.5	-582.0	-8.2	35.1	-86.4	47.4	22.5	-73.9	48.5
1.030	-139.6	-627.6	-580.2	-16.7	33.4	-80.9	43.7	21.1	-68.7	44.7
1.044	-137.0	-620.6	-577.8	-24.5	31.8	-76.0	40.4	19.9	-64.2	41.3
1.059	-134.8	-613.7	-575.1	-32.2	30.3	-71.1	37.1	18.7	-59.6	37.9
1.074	-130.9	-607.2	-572.9	-39.6	29.0	-66.8	34.2	17.7	-55.7	34.9
1.089	-127.0	-600.5	-570.9	-46.9	27.7	-62.6	31.3	16.7	-51.7	31.9
1.103	-122.2	-594.5	-568.6	-53.8	26.6	-59.0	28.9	15.8	-48.4	29.5
1.118	-116.6	-588.1	-565.8	-60.7	25.4	-55.3	26.4	15.0	-45.0	26.9
1.133	-110.0	-581.9	-565.2	-67.1	24.4	-52.2	24.4	14.3	-42.1	24.8
1.148	-103.5	-575.8	-563.1	-73.6	23.4	-49.1	22.3	13.5	-39.3	22.6
1.162	-95.9	-569.8	-562.9	-79.7	22.5	-46.4	20.6	12.9	-36.9	20.8
1.177	-88.6	-563.8	-565.5	-85.9	21.7	-43.8	18.9	12.3	-34.5	19.0
1.194	-78.6	-556.7	-551.2	-92.7	20.7	-41.1	17.2	11.6	-32.0	17.3
1.212	-68.6	-549.6	-533.7	-99.6	19.8	-38.4	15.5	11.0	-29.6	15.6
1.230	-58.4	-542.6	-509.1	-105.5	19.0	-36.2	14.2	10.4	-27.7	14.2
1.248	-48.3	-535.7	-486.2	-111.4	18.2	-33.9	12.8	9.9	-25.7	12.9
1.266	-37.7	-528.8	-463.8	-116.1	17.6	-32.1	11.7	9.4	-24.1	11.8
1.283	-27.2	-522.0	-441.7	-121.0	16.9	-30.2	10.6	8.9	-22.4	10.7
1.300	-16.9	-515.2	-420.5	-125.0	16.3	-28.6	9.8	8.5	-21.1	9.8
1.319	-6.5	-508.4	-399.3	-128.9	15.6	-27.1	8.9	8.1	-19.7	9.0
1.336	3.6	-501.7	-379.2	-132.3	15.1	-25.7	8.2	7.8	-18.6	8.2
1.354	13.7	-495.0	-359.2	-135.6	14.6	-24.4	7.5	7.4	-17.4	7.5
1.372	23.5	-488.4	-340.2	-138.1	14.1	-23.3	6.9	7.1	-16.4	6.9
1.390	33.3	-481.8	-321.1	-140.8	13.6	-22.1	6.3	6.8	-15.5	6.4
1.410	44.4	-474.2	-300.2	-143.1	13.1	-20.9	5.7	6.5	-14.5	5.8
1.431	55.4	-466.6	-279.2	-145.4	12.6	-19.8	5.2	6.2	-13.5	5.2
1.451	66.0	-459.1	-259.6	-147.0	12.2	-18.8	4.7	5.9	-12.7	4.8
1.472	76.5	-451.7	-240.0	-148.6	11.7	-17.8	4.3	5.7	-11.9	4.3
1.493	86.5	-444.3	-221.7	-149.6	11.3	-17.0	3.9	5.4	-11.2	4.0
1.513	96.5	-437.0	-203.3	-150.6	10.9	-16.1	3.5	5.2	-10.6	3.6
1.534	106.1	-429.8	-186.0	-151.1	10.6	-15.4	3.2	5.0	-10.0	3.3
1.555	115.6	-422.5	-168.9	-151.5	10.2	-14.7	2.9	4.8	-9.3	3.0
1.575	124.6	-415.5	-152.7	-151.5	99.2	-14.0	2.7	4.6	-8.9	2.7
1.596	133.9	-408.4	-136.4	-151.6	96.1	-13.4	2.4	4.5	-8.3	2.5
1.617	142.4	-401.5	-121.3	-151.2	93.2	-12.8	2.2	4.3	-7.9	2.2
1.637	151.0	-394.6	-106.1	-150.8	90.4	-12.2	2.0	4.1	-7.4	2.0
1.658	159.3	-387.7	-91.8	-150.1	87.9	-11.7	1.8	4.0	-7.0	1.8
1.679	167.6	-380.8	-77.3	-149.3	85.3	-11.2	1.6	3.9	-6.7	1.7
1.708	178.6	-371.4	-58.3	-147.8	82.0	-10.5	1.4	3.7	-6.2	1.4
1.738	189.6	-361.9	-39.4	-146.3	78.8	-99.0	1.2	3.5	-5.7	1.2
1.767	199.9	-352.6	-21.9	-144.3	76.0	-93.5	1.0	3.4	-5.3	1.1
1.797	210.3	-343.4	-4.4	-142.2	73.2	-88.0	.8	3.2	-4.9	.9
1.826	219.9	-334.5	11.7	-139.8	70.7	-83.2	.7	3.1	-4.5	.8
1.856	229.6	-325.5	27.9	-137.3	68.2	-78.4	.5	3.0	-4.1	.6
1.900	242.9	-312.5	50.0	-133.1	64.9	-72.2	.4	2.8	-3.7	.4
1.944	256.1	-299.6	71.9	-128.8	61.8	-66.1	.2	2.7	-3.2	.3
1.989	268.1	-287.2	91.4	-124.0	59.1	-61.0	.1	2.6	-2.9	.2
2.033	285.5	-274.7	116.4	-119.1	56.4	-55.3	-.1	2.4	-2.5	.0
2.092	280.3	-259.4	119.9	-112.5	53.5	-51.4	-.1	2.3	-2.2	-.0
2.151	268.9	-244.1	117.1	-105.9	50.5	-48.1	-.1	2.2	-2.1	-.1

Tab 4 continued....

RADIAL POSITN (1)	STRESSES (MPa)				STRAINS ($\times 10^{-3}$)					
	LOADED		UNLOADED		LOADED			UNLOADED		
	CIRC.	RAD.	CIRC.	RAD.	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE
2.210	254.9	-231.1	110.5	-100.3	48.0	-45.7	-.1	2.1	-2.0	-.0
2.269	242.0	-218.2	104.9	-94.7	45.5	-43.2	-.1	2.0	-1.9	-.0
2.328	230.9	-207.1	100.1	-89.8	43.4	-41.1	-.1	1.9	-1.8	-.0
2.387	219.8	-196.0	95.3	-85.0	41.2	-38.9	-.1	1.8	-1.7	-.0
2.446	210.2	-186.5	91.1	-80.9	39.4	-37.1	-.1	1.7	-1.6	-.0
2.505	200.7	-176.9	87.0	-76.7	37.6	-35.3	-.1	1.6	-1.5	-.0
2.564	192.4	-168.6	83.4	-73.1	36.0	-33.7	-.1	1.6	-1.5	-.0
2.623	184.0	-160.2	79.7	-69.5	34.3	-32.0	-.1	1.5	-1.4	-.0
2.711	173.4	-149.6	75.1	-64.9	32.3	-30.0	-.1	1.4	-1.3	-.0
2.800	162.5	-138.7	70.4	-60.2	30.2	-27.9	-.1	1.3	-1.2	-.0
2.977	146.2	-122.4	63.3	-53.1	27.0	-24.7	-.1	1.2	-1.1	-.0

1. Radial distance from hole centre is expressed non-dimensionally as a ratio to hole radius.
2. Quoted values are from pre-determined pressure loading on Fig.2(c) mesh.

TABLE 5. Stress and Strain Distributions versus Radial Position
- at 5% Interference and after Unloading - Plane Stress
(see note 2).

RADIAL POSITN (1)	STRESSES (MPa)				STRAINS ($\times 10^{-3}$)					
	LOADED		UNLOADED		LOADED		UNLOADED			
	CIRC.	RAD.	CIRC.	RAD.	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE
1.000	-130.7	-674.6	-622.6	1.0	46.5	-120.8	70.3	32.8	-107.3	71.4
1.015	-133.1	-667.0	-617.6	-8.6	44.2	-114.1	65.9	30.9	-100.9	67.0
1.030	-135.2	-659.4	-613.0	-17.8	41.9	-107.3	61.5	29.0	-94.6	62.5
1.044	-136.6	-652.1	-609.8	-25.9	39.9	-101.2	57.4	27.3	-88.8	58.3
1.059	-138.4	-645.2	-605.8	-34.5	37.9	-95.2	53.4	25.7	-83.1	54.3
1.074	-137.3	-637.8	-601.7	-41.7	36.2	-89.7	49.6	24.3	-77.9	50.5
1.089	-136.9	-630.8	-598.9	-49.3	34.5	-84.2	45.9	22.9	-72.7	46.7
1.103	-136.1	-624.7	-596.5	-56.9	33.0	-79.5	42.3	21.7	-68.4	43.5
1.118	-134.3	-618.0	-592.8	-64.0	31.5	-74.7	39.5	20.5	-63.8	40.1
1.133	-131.4	-611.8	-590.1	-70.7	30.2	-70.4	36.6	19.4	-59.9	37.2
1.148	-128.1	-605.4	-587.4	-77.3	28.9	-66.2	33.7	18.4	-55.9	34.2
1.162	-124.0	-599.5	-585.3	-83.8	27.7	-62.5	31.3	17.5	-52.5	31.7
1.177	-120.1	-593.6	-583.5	-90.3	26.6	-58.9	28.8	16.6	-49.1	29.1
1.194	-112.8	-586.4	-581.3	-97.3	25.4	-55.1	26.3	15.7	-45.6	26.5
1.212	-106.3	-579.5	-581.6	-104.7	24.2	-51.3	23.8	14.8	-42.1	23.9
1.230	-98.2	-572.7	-569.5	-111.3	23.1	-48.2	21.7	14.0	-39.2	21.8
1.248	-89.7	-565.8	-553.4	-117.9	22.1	-45.0	19.7	13.3	-36.3	19.7
1.266	-80.7	-559.1	-530.5	-123.6	21.2	-42.4	18.0	12.6	-33.9	18.1
1.283	-71.8	-552.5	-509.2	-129.2	20.3	-39.8	16.3	12.0	-31.5	16.4
1.300	-62.0	-545.8	-488.0	-134.0	19.6	-37.5	15.0	11.4	-29.2	15.0
1.319	-52.5	-539.2	-467.1	-138.9	18.8	-35.3	13.6	10.9	-27.6	13.7
1.336	-42.8	-532.8	-446.9	-142.9	18.1	-33.5	12.5	10.4	-25.9	12.6
1.354	-32.9	-526.2	-426.5	-146.9	17.4	-31.6	11.4	9.9	-24.2	11.5
1.372	-23.5	-520.0	-407.3	-150.2	16.8	-30.0	10.5	9.5	-22.9	10.6
1.390	-13.9	-513.6	-388.0	-153.6	16.2	-28.5	9.6	9.1	-21.5	9.7
1.410	-2.4	-506.1	-366.1	-156.6	15.6	-26.9	8.8	8.6	-20.1	8.8
1.431	8.6	-498.7	-344.5	-159.7	15.0	-25.3	7.9	8.2	-18.7	8.0
1.451	19.4	-491.5	-324.2	-162.0	14.4	-24.0	7.2	7.9	-17.6	7.3
1.472	30.3	-484.2	-303.8	-164.4	13.9	-22.7	6.6	7.5	-16.5	6.6
1.493	40.6	-477.1	-284.6	-166.0	13.4	-21.6	6.0	7.2	-15.5	6.1
1.513	51.1	-469.9	-265.3	-167.6	12.9	-20.4	5.5	6.9	-14.5	5.5
1.534	61.0	-462.8	-247.3	-168.7	12.5	-19.5	5.0	6.6	-13.7	5.1
1.555	70.9	-455.9	-229.3	-169.8	12.1	-18.5	4.6	6.3	-12.9	4.6
1.575	80.5	-448.9	-212.2	-170.3	11.7	-17.7	4.2	6.1	-12.2	4.2
1.596	90.2	-441.8	-195.0	-170.8	11.3	-16.8	3.8	5.8	-11.5	3.9
1.617	99.3	-435.1	-179.0	-170.9	10.9	-16.1	3.5	5.6	-10.9	3.6
1.637	108.3	-428.3	-163.1	-171.0	10.6	-15.3	3.2	5.4	-10.3	3.2
1.658	117.0	-421.6	-148.0	-170.8	10.3	-14.7	2.9	5.2	-9.8	3.0
1.679	125.8	-414.8	-132.7	-170.5	10.0	-14.0	2.6	5.1	-9.3	2.7
1.708	137.6	-405.4	-112.5	-169.5	9.6	-13.2	2.3	4.8	-8.6	2.4
1.738	149.3	-396.1	-92.3	-168.5	9.2	-12.4	2.0	4.6	-8.0	2.1
1.767	160.4	-386.9	-73.8	-167.0	8.8	-11.7	1.8	4.4	-7.4	1.8
1.797	171.3	-377.8	-55.3	-165.5	8.5	-11.1	1.5	4.2	-6.9	1.6
1.826	181.6	-368.9	-38.1	-163.4	8.2	-10.5	1.3	4.0	-6.4	1.4
1.856	192.0	-360.0	-20.7	-161.4	7.9	-9.9	1.1	3.9	-6.0	1.2
1.900	206.3	-347.0	2.6	-157.7	7.5	-9.1	.9	3.6	-5.4	1.0
1.944	220.4	-334.2	25.9	-154.0	7.1	-8.4	.7	3.4	-4.8	.7
1.989	233.4	-321.8	46.9	-149.6	6.8	-7.7	.5	3.3	-4.3	.6
2.033	246.4	-309.5	67.9	-145.3	6.5	-7.1	.3	3.1	-3.9	.4
2.092	261.8	-293.8	92.6	-138.7	6.1	-6.4	.2	2.9	-3.4	.2
2.151	280.3	-278.0	120.2	-132.2	5.8	-5.7	.0	2.7	-2.8	.0

Table 5 continued....

RADIAL POSITN (1)	STRESSES (MPa)				STRAINS ($\times 10^{-3}$)					
	LOADED		UNLOADED		LOADED			UNLOADED		
	CIRC.	RAD.	CIRC.	RAD.	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE
2.210	282.5	-263.4	130.1	-125.2	5.5	-5.3	-.1	2.6	-2.6	-.0
2.269	278.7	-248.8	134.0	-118.4	5.2	-4.9	-.1	2.5	-2.3	-.1
2.328	263.2	-236.1	125.1	-112.3	4.9	-4.7	-.1	2.4	-2.2	-.1
2.387	250.5	-223.4	119.1	-106.3	4.7	-4.4	-.1	2.2	-2.1	-.1
2.446	289.6	-212.5	113.9	-101.1	4.5	-4.2	-.1	2.1	-2.0	-.1
2.505	228.7	-201.7	108.7	-95.9	4.3	-4.0	-.1	2.0	-1.9	-.1
2.564	219.3	-192.2	104.2	-91.4	4.1	-3.8	-.1	1.9	-1.8	-.1
2.623	209.7	-182.6	99.7	-86.9	3.9	-3.7	-.1	1.9	-1.7	-.1
2.711	197.6	-170.5	93.9	-81.1	3.7	-3.4	-.1	1.8	-1.6	-.1
2.800	185.2	-158.1	88.0	-75.2	3.4	-3.2	-.1	1.6	-1.5	-.1
2.977	166.6	-139.5	79.2	-66.4	3.1	-2.8	-.1	1.5	-1.3	-.1

1. Radial distance from hole centre is expressed non-dimensionally as a ratio to hole radius
2. Quoted values are from pre-determined pressure loading on Fig.2(c) mesh.

TABLE 6. Stress and Strain Distributions versus Radial Position
- at 2% Interference and after Unloading - Plane Strain.
 (see note 2).

RADIAL POSITN (1)	STRESSES (MPa)						STRAINS ($\times 10^{-3}$)			
	LOADED			UNLOADED			LOADED		UNLOADED	
	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	CIRC.	RAD.
1.000	-19.3	-577.4	-196.9	-572.9	-1.8	-189.6	18.7	-24.8	7.4	-13.5
1.014	-14.1	-570.5	-192.9	-572.6	-11.2	-192.6	18.1	-24.0	7.1	-13.1
1.029	-8.5	-563.5	-188.7	-567.5	-20.3	-193.9	17.5	-23.2	6.9	-12.7
1.043	-3	-555.7	-183.5	-540.1	-27.4	-187.2	16.9	-22.4	6.6	-12.1
1.058	6.9	-548.1	-178.6	-518.1	-34.7	-182.4	16.4	-21.6	6.3	-11.6
1.072	14.5	-540.4	-173.5	-496.7	-40.7	-177.3	15.9	-20.8	6.1	-11.1
1.087	22.3	-532.6	-168.4	-475.2	-46.6	-172.2	15.4	-20.1	5.8	-10.7
1.101	29.2	-525.4	-163.7	-455.7	-52.1	-167.5	14.9	-19.5	5.6	-10.3
1.116	36.1	-515.7	-158.2	-436.1	-55.1	-162.1	14.5	-18.8	5.4	-9.9
1.139	46.4	-506.5	-151.8	-407.3	-64.3	-155.6	16.8	-17.9	5.2	-9.3
1.163	57.3	-497.2	-145.1	-378.0	-73.5	-148.9	13.2	-17.0	4.9	-8.8
1.192	71.2	-481.0	-135.2	-344.1	-77.3	-139.0	12.5	-16.0	4.6	-8.1
1.221	84.8	-469.5	-126.9	-310.5	-85.9	-130.7	11.8	-15.0	4.2	-7.5
1.250	95.9	-455.0	-118.5	-282.1	-88.6	-122.3	11.2	-14.1	4.0	-7.0
1.279	109.2	-441.4	-109.6	-251.4	-92.4	-113.4	10.6	-13.2	3.7	-6.4
1.314	124.1	-428.0	-100.3	-218.6	-97.0	-104.1	10.0	-12.3	3.5	-5.9
1.349	137.4	-412.4	-90.7	-187.3	-99.5	-94.6	9.4	-11.5	3.2	-5.4
1.395	156.1	-394.7	-78.7	-148.5	-101.7	-82.6	8.7	-10.5	2.9	-4.8
1.442	174.1	-376.2	-66.6	-110.4	-103.2	-70.5	8.1	-9.6	2.7	-4.2
1.500	195.1	-354.8	-52.6	-69.3	-101.9	-56.5	7.5	-8.6	2.5	-3.7
1.558	216.2	-333.4	-38.6	-28.2	-100.6	-42.5	6.9	-7.7	2.2	-3.1
1.617	235.6	-313.6	-25.7	7.0	-96.7	-29.5	6.4	-6.9	2.1	-2.7
1.675	255.8	-293.8	-12.5	43.2	-92.9	-16.3	5.9	-6.2	1.9	-2.2
1.733	272.5	-275.4	-9	72.9	-87.5	-4.8	5.5	-5.6	1.8	-1.9
1.791	281.0	-256.8	7.9	94.4	-81.9	4.1	5.2	-5.0	1.6	-1.6
1.849	258.1	-241.0	5.6	82.1	-76.7	1.7	4.9	-4.8	1.5	-1.5
1.908	242.4	-225.3	5.6	77.1	-71.7	1.7	4.6	-4.5	1.5	-1.4
1.966	229.4	-212.3	5.6	72.9	-67.6	1.7	4.3	-4.2	1.4	-1.3
2.024	216.3	-199.2	5.6	68.8	-63.4	1.7	4.1	-4.0	1.3	-1.3
2.082	205.3	-188.3	5.6	65.3	-59.9	1.7	3.9	-3.7	1.2	-1.2
2.141	194.4	-177.3	5.6	61.8	-56.4	1.7	3.6	-3.5	1.2	-1.1
2.199	185.0	-168.0	5.6	58.8	-53.5	1.7	3.5	-3.3	1.1	-1.1
2.257	175.7	-158.6	5.6	55.9	-50.5	1.7	3.3	-3.2	1.0	-1.0
2.315	167.7	-150.6	5.6	53.3	-48.0	1.7	3.1	-3.0	1.0	-1.0
2.373	159.7	-142.6	5.6	50.8	-45.4	1.7	3.0	-2.9	.9	-.9
2.432	152.8	-135.7	5.6	48.6	-43.2	1.7	2.8	-2.7	.9	-.9
2.490	145.9	-128.9	5.6	46.4	-41.0	1.7	2.7	-2.6	.9	-.8
2.548	139.9	-122.9	5.6	44.5	-39.1	1.7	2.6	-2.5	.8	-.8
2.606	133.9	-116.9	5.6	42.6	-37.2	1.7	2.5	-2.4	.8	-.8
2.664	128.8	-111.6	5.6	40.9	-35.5	1.7	2.4	-2.3	.8	-.7
2.723	123.4	-106.3	5.6	39.2	-33.8	1.7	2.3	-2.2	.7	-.7
2.810	116.6	-99.5	5.6	37.1	-31.7	1.7	2.1	-2.0	.7	-.6
2.897	109.7	-92.6	5.6	34.9	-29.5	1.7	2.0	-2.0	.6	-.6
3.072	99.2	-82.1	5.6	31.5	-26.1	1.7	1.8	-1.7	.6	-.5

1. Radial distance from hole centre is expressed non-dimensionally as a ratio to hole radius.
2. Quoted values are from displacement loading on Fig.2(a) mesh.

TABLE 7. Stress and Strain Distributions versus Radial Position
- at 3% Interference and after Unloading - Plane Strain.
(see note 2).

RADIAL POSITN (1)	STRESSES (MPa)						STRAINS ($\times 10^{-3}$)			
	LOADED			UNLOADED			LOADED		UNLOADED	
	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	CIRC.	RAD.
1.000	-100.5	-677.7	-256.8	589.5	4.8	-193.0	28.4	-38.8	14.7	-24.6
1.014	-94.8	-670.9	-252.6	-594.8	-5.8	-198.2	27.4	-37.5	14.2	-23.8
1.029	-88.5	-663.6	-248.2	-601.3	-15.2	-203.5	26.5	-36.2	13.6	-22.9
1.043	-81.3	-655.4	-243.1	-606.5	-23.0	-207.7	25.6	-34.9	13.1	-22.1
1.058	-74.7	-647.6	-238.3	-611.6	-31.8	-212.3	24.8	-33.7	12.6	-21.3
1.072	-67.1	-639.2	-233.0	-616.3	-38.6	-216.1	24.0	-32.6	12.2	-20.6
1.087	-59.6	-631.0	-227.9	-621.1	-46.1	-220.2	23.3	-31.4	11.7	-19.9
1.101	-53.8	-624.1	-223.6	-624.7	-54.2	-224.0	22.6	-30.5	11.4	-19.3
1.116	-47.1	-617.2	-219.2	-621.4	-62.5	-225.7	21.9	-29.5	11.0	-18.7
1.139	-36.0	-604.6	-211.4	-582.9	-72.4	-216.3	20.9	-28.0	10.4	-17.6
1.163	-25.4	-592.2	-203.8	-549.9	-82.2	-208.6	19.9	-26.6	9.9	-16.6
1.192	-12.8	-579.5	-195.5	-513.1	-93.6	-200.2	18.8	-25.0	9.2	-15.5
1.221	-9	-565.4	-186.9	-477.0	-103.6	-191.6	17.8	-23.5	8.6	-14.4
1.250	12.1	-552.6	-178.4	-443.1	-111.5	-183.0	16.8	-22.1	8.1	-13.5
1.279	25.6	-539.4	-169.6	-408.7	-119.2	-174.2	15.8	-20.7	7.5	-12.5
1.314	38.7	-524.5	-160.3	-373.9	-125.9	-165.0	15.0	-19.5	7.0	-11.6
1.349	52.0	-510.2	-151.2	-339.0	-133.2	-155.8	14.1	-18.2	6.6	-10.8
1.395	70.3	-490.9	-138.8	-296.5	-138.0	-143.4	13.1	-16.7	6.0	-9.8
1.442	88.7	-471.7	-126.4	-254.1	-142.9	-131.0	12.1	-15.3	5.5	-8.8
1.500	109.6	-450.2	-112.4	-208.9	-145.7	-117.0	11.1	-13.9	5.0	-7.9
1.558	130.4	-428.8	-98.5	-164.0	-148.4	-103.1	10.2	-12.5	4.5	-7.0
1.617	148.9	-409.0	-85.8	-126.3	-147.8	-90.5	9.4	-11.4	4.1	-6.2
1.675	169.0	-389.0	-72.6	-87.0	-147.1	-77.2	8.6	-10.2	3.7	-5.4
1.733	187.5	-370.5	-60.4	-52.9	-144.2	-65.0	8.0	-9.4	3.5	-4.9
1.791	204.6	-351.6	-48.5	-20.1	-140.8	-53.1	7.0	-8.5	3.2	-4.3
1.849	221.7	-334.1	-37.1	9.8	-136.2	-41.7	7.1	-7.8	3.0	-3.8
1.908	238.6	-316.5	-25.7	39.6	-131.5	-30.3	6.5	-7.1	2.7	-3.4
1.966	254.4	-300.3	-15.1	66.1	-126.0	-19.8	6.2	-6.5	2.6	-3.0
2.024	272.2	-284.1	-3.9	94.6	-120.5	-8.5	5.8	-5.9	2.4	-2.6
2.082	280.5	-268.5	4.0	111.9	-113.7	-6	5.5	-5.4	2.3	-2.3
2.141	282.2	-252.9	9.7	122.6	-107.4	5.0	5.2	-5.0	2.2	-2.1
2.199	264.1	-239.5	8.1	112.2	-101.6	3.4	4.9	-4.8	2.0	-2.0
2.257	250.7	-226.3	8.0	106.4	-96.1	3.4	4.7	-4.5	1.9	-1.9
2.315	239.3	-214.9	8.0	101.6	-91.2	3.4	4.5	-4.3	1.8	-1.8
2.373	227.9	-203.6	8.0	96.7	-86.5	3.3	4.2	-4.1	1.8	-1.7
2.432	218.1	-193.7	8.0	92.6	-82.3	3.4	4.0	-3.9	1.7	-1.6
2.490	208.2	-183.9	8.0	88.4	-78.1	3.4	3.9	-3.7	1.6	-1.5
2.548	199.7	-175.4	8.0	84.8	-74.5	3.4	3.7	-3.5	1.5	-1.5
2.606	191.1	-166.8	8.0	81.2	-70.8	3.4	3.5	-3.4	1.4	-1.4
2.664	183.6	-159.3	8.0	78.0	-67.7	3.3	3.4	-3.2	1.4	-1.3
2.723	176.1	-151.8	8.0	74.7	-64.5	3.4	3.2	-3.1	1.3	-1.3
2.810	166.4	-142.1	8.0	70.7	-60.4	3.4	3.1	-2.9	1.2	-1.2
2.897	156.5	-132.2	8.0	66.4	-56.2	3.4	2.9	-2.7	1.2	-1.1
3.072	141.5	-117.2	8.0	60.1	-49.8	3.4	2.6	-2.4	1.0	-1.0

1. Radial distance from hole centre is expressed non-dimensionally as a ratio to hole radius.
2. Quoted values are from displacement loading on Fig. 2(a) mesh.

TABLE 8. Stress and Strain Distributions versus Radial Position
- at 4% Interference and after Unloading - Plane Strain.
(see note 2).

RADIAL POSITN (1)	STRESSES (MPa)						STRAINS ($\times 10^{-3}$)			
	LOADED			UNLOADED			LOADED		UNLOADED	
	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	CIRC.	RAD.
1.000	-158.2	-748.4	-299.2	-614.3	1.4	-202.3	38.2	-53.4	23.0	-37.3
1.014	-151.9	-739.9	-294.3	-618.5	-7.8	-206.7	36.9	-51.5	22.1	-36.0
1.029	-146.0	-732.1	-289.8	-623.8	-17.8	-211.7	35.7	-49.7	21.3	-34.7
1.043	-139.7	-724.2	-285.1	-629.5	-25.9	-216.3	34.5	-47.9	20.5	-33.4
1.058	-133.5	-716.4	-280.5	-633.4	-34.5	-220.4	33.3	-46.2	19.8	-32.2
1.072	-126.3	-707.7	-275.2	-636.8	-42.5	-224.1	32.3	-44.7	19.1	-31.0
1.087	-119.0	-699.0	-269.9	-641.9	-49.0	-228.0	31.2	-43.1	18.4	-30.0
1.101	-113.2	-692.3	-265.8	-647.4	-58.3	-232.9	30.3	-41.8	17.8	-29.0
1.116	-107.0	-682.7	-260.6	-651.6	-66.0	-236.8	29.4	-40.4	17.2	-28.0
1.139	-97.3	-672.8	-254.1	-659.8	-77.9	-243.4	28.1	-38.4	16.4	-26.6
1.163	-86.9	-662.9	-247.4	-670.4	-90.3	-251.0	26.7	-36.4	15.5	-25.3
1.192	-74.5	-647.1	-238.1	-634.0	-102.9	-243.2	25.2	-34.3	14.5	-23.7
1.221	-62.4	-635.3	-230.2	-595.5	-118.3	-235.6	23.8	-32.1	13.6	-22.1
1.250	-50.9	-619.8	-221.3	-560.5	-125.8	-226.5	22.5	-30.3	12.8	-20.7
1.279	-37.9	-607.7	-212.7	-524.1	-136.1	-217.9	21.2	-28.4	11.9	-19.3
1.314	-23.9	-591.7	-203.2	-485.8	-145.5	-208.3	20.0	-26.7	11.2	-18.0
1.349	-11.0	-574.8	-193.3	-448.7	-152.7	-198.5	18.8	-24.9	10.5	-16.7
1.395	6.9	-557.9	-181.8	-403.8	-162.9	-187.0	17.4	-23.0	9.6	-15.2
1.442	24.9	-538.7	-169.5	-358.7	-170.7	-174.7	16.0	-21.0	8.7	-13.8
1.500	45.6	-516.8	-155.5	-310.9	-176.0	-160.7	14.8	-19.1	8.0	-12.4
1.558	65.9	-495.3	-141.7	-263.6	-181.4	-146.8	13.5	-17.3	7.2	-11.1
1.617	85.3	-475.2	-128.7	-222.7	-182.9	-133.8	12.4	-15.7	6.6	-10.0
1.675	105.0	-455.2	-115.6	-184.4	-181.5	-120.8	11.4	-14.2	5.9	-8.9
1.733	122.7	-435.9	-103.4	-146.3	-182.6	-108.5	10.6	-13.1	5.5	-8.1
1.791	141.0	-418.0	-91.4	-110.5	-182.2	-96.6	9.9	-12.0	5.1	-7.4
1.849	158.2	-399.9	-79.8	-79.0	-178.5	-85.0	9.2	-11.0	4.7	-6.7
1.908	175.0	-382.3	-68.4	-47.7	-175.2	-73.6	8.5	-10.1	4.4	-6.0
1.966	190.8	-366.2	-57.9	-19.9	-171.1	-63.0	8.1	-9.3	4.1	-5.5
2.024	206.7	-349.7	-47.2	8.0	-166.6	-52.3	7.6	-8.6	3.8	-4.9
2.082	221.9	-334.2	-37.1	33.2	-161.1	-42.2	7.1	-7.9	3.6	-4.5
2.141	237.0	-318.4	-26.9	58.4	-155.5	-32.0	6.7	-7.3	3.4	-4.0
2.199	251.0	-304.0	-17.5	81.0	-149.6	-22.6	6.4	-6.7	3.2	-3.6
2.257	265.3	-289.2	-7.9	103.8	-143.4	-13.0	6.0	-6.2	3.0	-3.2
2.315	278.6	-275.5	1.0	124.5	-137.0	-4.1	5.7	-5.7	2.9	-2.9
2.373	291.9	-261.1	10.2	145.2	-130.0	5.0	5.4	-5.2	2.7	-2.6
2.432	279.9	-248.7	10.3	139.4	-123.9	5.1	5.2	-5.0	2.6	-2.5
2.490	267.2	-236.1	10.3	133.1	-117.6	5.1	5.0	-4.7	2.5	-2.4
2.548	256.2	-225.1	10.3	127.6	-112.2	5.1	4.7	-4.5	2.4	-2.3
2.606	245.3	-214.0	10.3	122.3	-106.6	5.2	4.5	-4.3	2.3	-2.2
2.664	235.7	-204.5	10.3	117.4	-101.9	5.1	4.3	-4.1	2.2	-2.1
2.723	226.0	-194.8	10.3	112.6	-97.1	5.1	4.2	-4.0	2.1	-2.0
2.810	213.6	-182.4	10.3	106.4	-90.9	5.1	3.9	-3.7	2.0	-1.9
2.897	200.9	-169.7	10.3	100.1	-84.6	5.1	3.7	-3.5	1.8	-1.7
3.072	181.6	-150.5	10.3	90.5	-75.0	5.1	3.3	-3.1	1.6	-1.5

1. Radial distance from hole centre is expressed non-dimensionally as a ratio to hole radius.

2. Quoted values are from displacement loading on Fig. 2(a) mesh.

TABLE 9. Stress and Strain Distributions versus Radial Position
- at 5% Interference and after Unloading - Plane Strain.
(see notes).

RADIAL POSITN (1)	STRESSES (MPa)						STRAINS (x10-3)			
	LOADED			UNLOADED			LOADED		UNLOADED	
	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	CIRC.	RAD.
1.000	-192.6	-802.7	-328.5	-634.3	-.0	-209.3	47.3	-67.2	30.7	-49.7
1.015	-186.2	-793.6	-323.4	-638.5	-8.9	-213.7	45.7	-64.7	29.5	-47.8
1.030	-180.1	-785.0	-318.5	-643.1	-18.2	-218.2	44.1	-62.3	28.4	-45.9
1.044	-174.2	-776.7	-313.8	-647.8	-27.2	-222.8	42.6	-60.1	27.4	-44.2
1.059	-168.0	-768.1	-308.9	-652.3	-6.5	-227.3	41.2	-57.9	26.4	-42.6
1.074	-161.7	-759.8	-304.1	-656.5	-4.5	-231.3	39.8	-56.0	25.5	-41.0
1.089	-155.4	-751.6	-299.3	-660.6	-2.4	-235.3	38.5	-54.0	24.6	-39.5
1.103	-149.5	-743.7	-294.8	-666.1	-1.0	-240.0	37.3	-52.2	23.7	-38.2
1.118	-143.5	-735.8	-290.2	-670.3	-8.8	-243.9	36.1	-50.4	22.9	-36.8
1.133	-137.1	-728.0	-285.5	-674.2	-6.5	-247.7	35.0	-48.8	22.2	-35.6
1.148	-131.2	-720.4	-281.0	-679.4	-4.8	-252.2	33.9	-47.1	21.4	-34.4
1.162	-125.3	-713.1	-276.7	-684.0	-2.2	-256.2	32.9	-45.7	20.7	-33.3
1.177	-118.8	-705.3	-272.0	-688.3	-9.2	-259.9	31.9	-44.2	20.0	-32.2
1.195	-111.7	-696.7	-266.8	-693.0	-17.9	-264.3	30.9	-42.5	19.3	-31.0
1.212	-105.1	-688.5	-261.9	-695.8	-17.1	-268.3	29.8	-40.9	18.5	-29.8
1.230	-97.7	-679.9	-256.6	-699.8	-14.9	-262.2	28.8	-39.5	17.9	-28.7
1.248	-90.2	-671.1	-251.2	-646.0	-12.3	-256.9	27.8	-38.0	17.2	-27.5
1.266	-83.5	-663.2	-246.4	-624.4	-19.2	-252.0	26.9	-36.7	16.6	-26.5
1.283	-76.8	-655.3	-241.6	-603.0	-16.4	-247.3	26.0	-35.4	16.0	-25.5
1.301	-69.7	-647.3	-236.6	-582.1	-12.0	-242.3	25.2	-34.2	15.5	-24.6
1.319	-62.9	-639.5	-231.8	-561.6	-17.8	-237.4	24.4	-33.0	14.9	-23.7
1.336	-56.3	-631.9	-227.1	-542.3	-12.8	-232.7	23.7	-32.0	14.4	-22.8
1.354	-49.3	-624.2	-222.3	-522.6	-17.7	-227.8	22.9	-30.9	13.9	-22.0
1.372	-42.8	-616.8	-217.7	-504.4	-12.1	-223.3	22.3	-29.9	13.5	-21.2
1.390	-36.1	-609.3	-213.0	-486.1	-16.4	-218.7	21.6	-28.9	13.0	-20.5
1.410	-28.7	-601.1	-207.8	-466.1	-10.8	-213.5	20.9	-27.9	12.6	-19.7
1.431	-21.1	-592.7	-202.6	-445.9	-15.0	-208.2	20.2	-26.9	12.1	-18.9
1.451	-13.6	-584.4	-197.4	-426.9	-18.2	-203.0	19.5	-25.9	11.7	-18.2
1.472	-6.0	-576.1	-192.1	-407.7	-11.3	-197.7	18.9	-25.0	11.2	-17.4
1.493	.9	-568.6	-187.4	-390.3	-14.5	-193.0	18.3	-24.1	10.9	-16.8
1.513	8.3	-560.7	-182.3	-372.4	-17.1	-188.0	17.7	-23.3	10.5	-16.2
1.534	15.4	-552.9	-177.4	-355.5	-19.2	-183.0	17.2	-22.5	10.1	-15.6
1.555	22.4	-545.4	-172.6	-338.7	-21.3	-178.2	16.6	-21.7	9.8	-15.0
1.575	29.4	-537.9	-167.8	-322.6	-22.7	-173.4	16.1	-21.0	9.4	-14.5
1.596	36.3	-530.5	-163.1	-306.9	-24.7	-168.9	15.6	-20.3	9.1	-13.9
1.617	43.1	-523.2	-158.4	-291.6	-26.5	-164.1	15.2	-19.7	8.9	-13.5
1.637	50.1	-515.8	-153.7	-276.2	-26.2	-159.2	14.8	-19.0	8.6	-13.0
1.658	56.5	-509.0	-149.3	-262.2	-27.4	-155.0	14.4	-18.5	8.3	-12.5
1.679	63.2	-501.9	-144.8	-247.8	-28.1	-150.5	13.9	-17.9	8.1	-12.1
1.708	72.4	-492.2	-138.5	-228.3	-28.4	-144.1	13.4	-17.1	7.7	-11.5
1.736	81.7	-482.4	-132.3	-209.1	-28.8	-137.9	12.9	-16.3	7.4	-11.0
1.767	90.8	-472.9	-126.2	-190.9	-28.4	-131.8	12.4	-15.7	7.1	-10.5
1.797	99.5	-463.6	-120.2	-173.0	-28.2	-125.8	12.0	-15.0	6.8	-9.9
1.826	108.3	-454.5	-114.3	-156.0	-27.3	-119.9	11.5	-14.4	6.5	-9.5
1.856	117.0	-445.4	-108.4	-139.0	-26.6	-114.0	11.1	-13.8	6.3	-9.0
1.900	129.5	-432.3	-99.9	-115.3	-24.5	-105.6	10.6	-13.0	5.9	-8.5
1.944	142.0	-419.2	-91.5	-91.8	-22.4	-97.1	10.0	-12.2	5.6	-7.9
1.989	153.9	-406.7	-83.4	-70.3	-19.6	-89.1	9.5	-11.5	5.3	-7.4
2.033	165.8	-394.3	-75.4	-48.7	-16.8	-81.0	9.0	-10.8	5.0	-6.9
2.092	181.1	-378.4	-65.1	-22.4	-11.9	-70.7	8.5	-10.0	4.7	-6.3

Table 9 continued....

RADIAL POSITN (1)	STRESSES (MPa)						STRAINS ($\times 10^{-3}$)			
	LOADED			UNLOADED			LOADED		UNLOADED	
	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	OUT OF PLANE	CIRC.	RAD.	CIRC.	RAD.
2.151	196.2	-362.6	-54.9	3.6	-17.1	-60.5	8.0	-9.2	4.4	-5.7
2.210	210.5	-347.7	-45.3	27.2	-11.6	-50.9	7.5	-8.6	4.2	-5.2
2.269	224.8	-332.8	-35.6	50.9	-15.9	-41.3	7.1	-7.9	3.9	-4.8
2.328	238.3	-318.7	-26.5	72.3	-19.8	-32.2	6.8	-7.4	3.7	-4.4
2.387	251.9	-304.6	-17.4	93.9	-13.6	-23.0	6.4	-6.7	3.5	-4.0
2.446	264.7	-291.2	-8.8	113.5	-17.2	-14.4	6.1	-6.3	3.3	-3.6
2.505	277.8	-277.8	.0	133.5	-10.6	-5.6	5.8	-5.8	3.2	-3.3
2.564	288.8	-265.0	7.8	150.5	-13.8	2.2	5.5	-5.4	3.0	-3.0
2.623	294.2	-252.1	13.9	161.9	-16.9	8.2	5.3	-5.1	2.9	-2.7
2.711	272.5	-235.3	12.3	147.9	-17.7	6.6	5.0	-4.8	2.7	-2.6
2.800	255.4	-218.1	12.3	138.6	-18.4	6.6	4.6	-4.4	2.5	-2.4
2.977	229.8	-192.5	12.3	124.7	-14.5	6.6	4.1	-3.9	2.3	-2.1

1. Radial distance from hole centre is expressed non-dimensionally as a ratio to hole radius.
2. Quoted values are from pre-determined pressure loading on Fig. 2(c) mesh.

TABLE 10. Hole Interface Displacements and Thickness Changes under Interference and After Unloading

INTERFERENCE LEVEL	STATE	RADIAL DISPLACEMENT (RATIO TO HOLE RADIUS)		THICKNESS PROPORTIONAL CHANGE	
		Interference	Unloaded	Interference	Unloaded
2%	Plane Stress	.0183	.0078	.0121	.0124
	Plane Strain	.0187	.0074	N/A	N/A
3%	Plane Stress	.0274	.0153	.0304	.0314
	Plane Strain	.0284	.0147	N/A	N/A
4%	Plane Stress	.0369	.0239	.0512	.0523
	Plane Strain	.0382	.0230	N/A	N/A
5%	Plane Stress	.0465	.0328	.0703	.0714
	Plane Strain	.0473	.0307	N/A	N/A

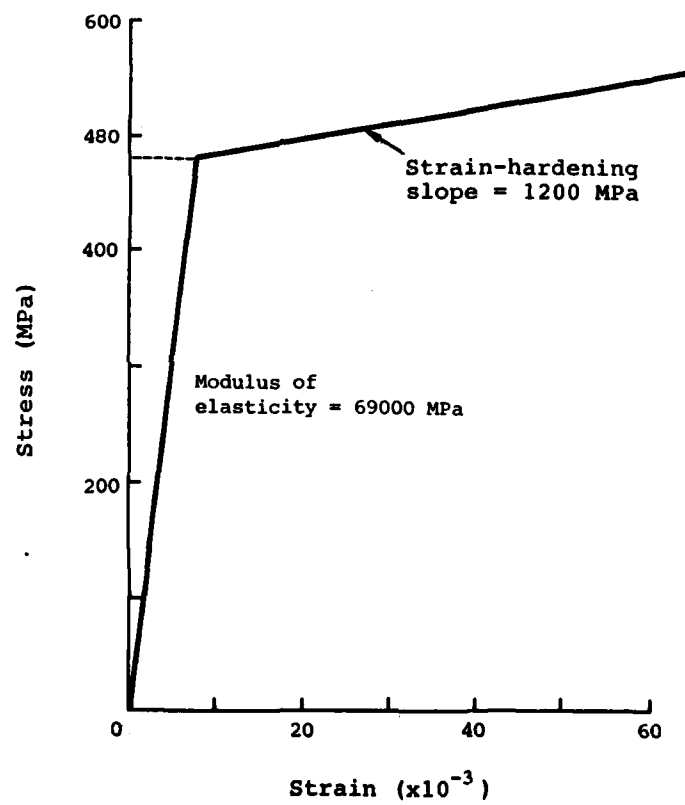


FIG 1. ASSUMED STRESS-STRAIN BEHAVIOUR FOR PLATE MATERIAL

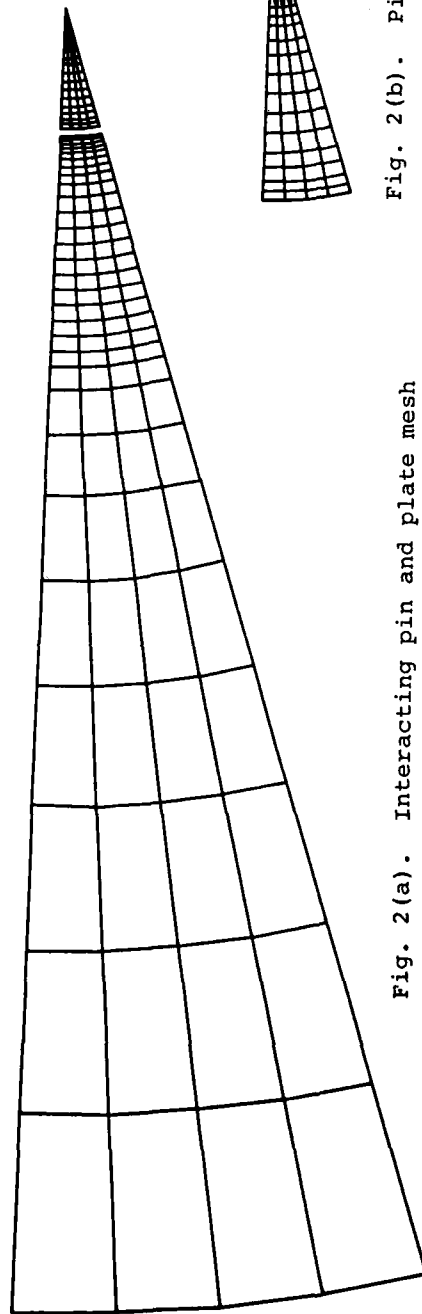


Fig. 2(a). Interacting pin and plate mesh

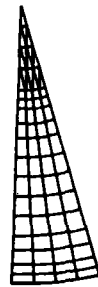


Fig. 2(b). Pin mesh

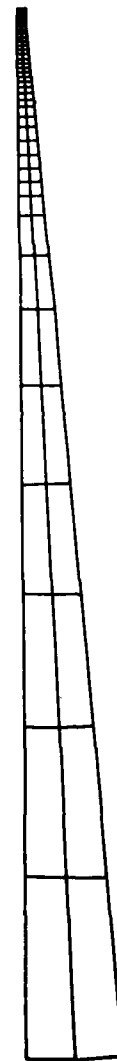


FIG. 2 (c). REDUCED PLATE MESH

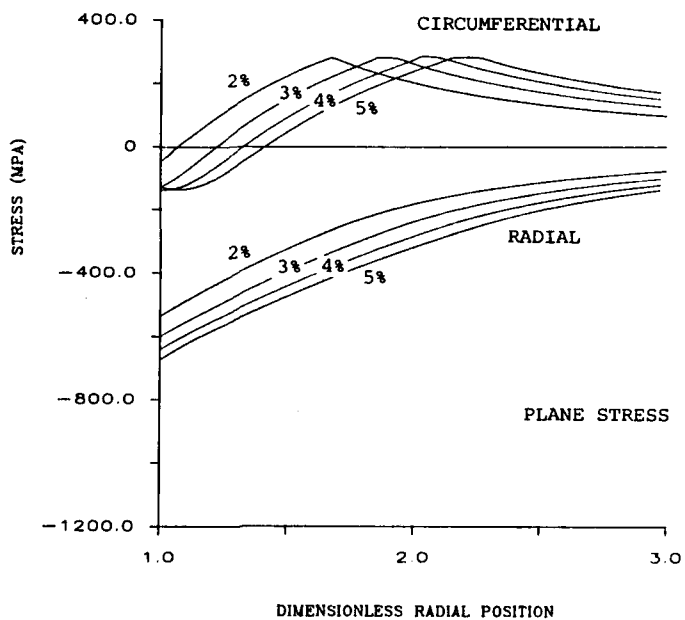


Fig. 3(a)

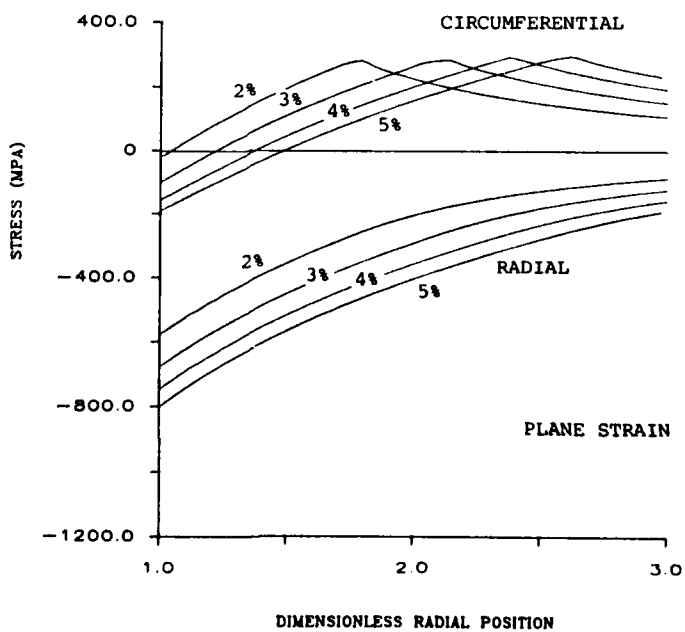


Fig. 3(b)

FIG. 3(a) & (b). CIRCUMFERENTIAL & RADIAL STRESSES IN PLATE AT 2%, 3%, 4% AND 5% INTERFERENCE

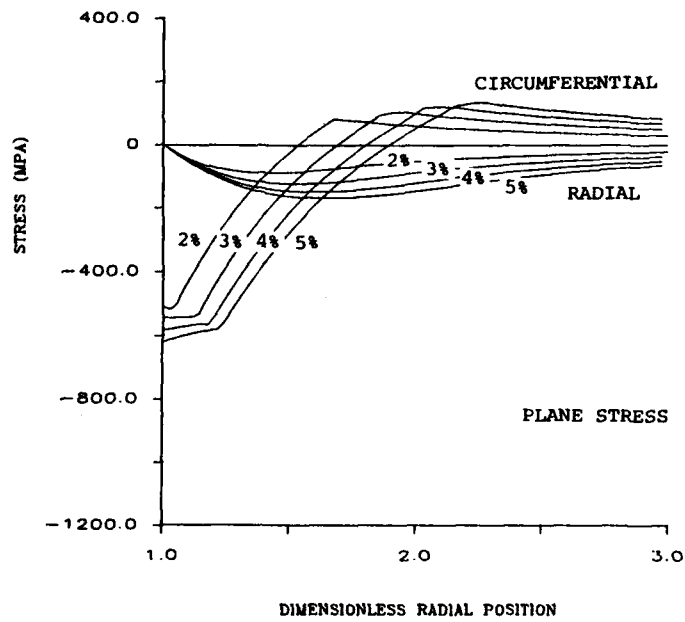


Fig. 4(a)

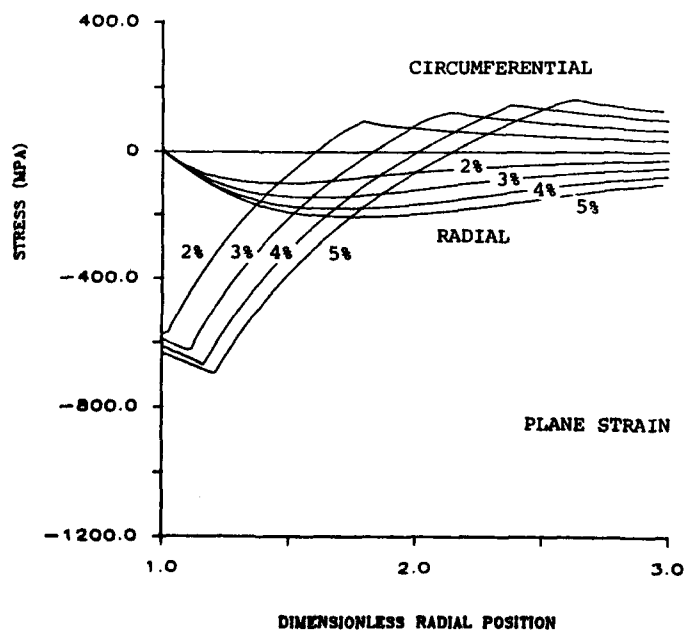


Fig. 4(b)

FIG. 4(a) & (b). RESIDUAL CIRCUMFERENTIAL AND RADIAL STRESSES IN PLATE AFTER 2%, 3%, 4%, AND 5% COLD-WORKING.

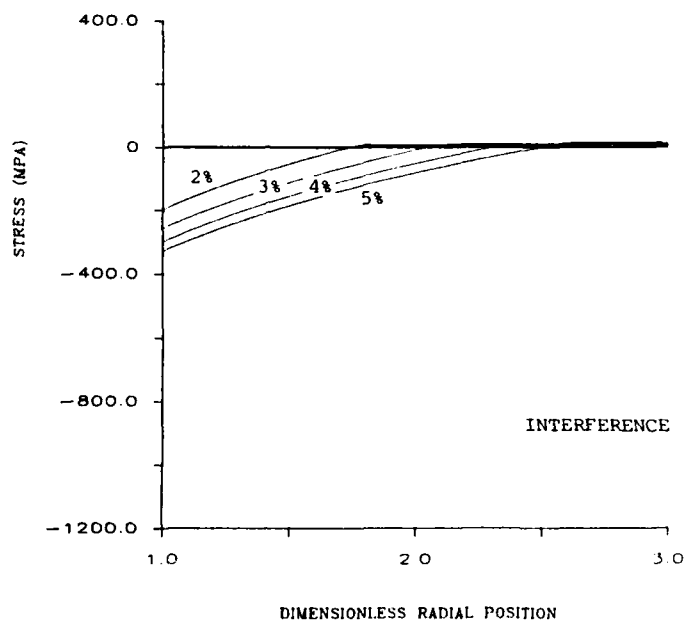


Fig. 5(a)

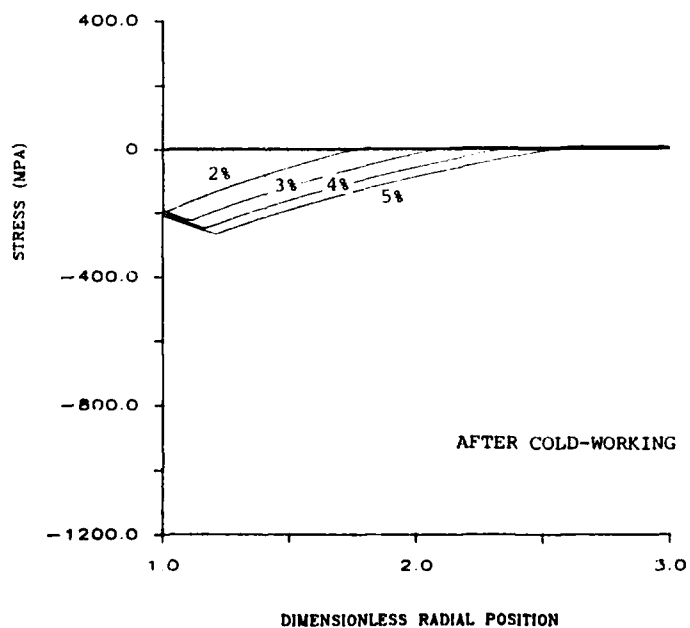


Fig. 5(b)

FIG. 5(a) & (b). OUT-OF-PLANE STRESSES IN PLATE AT 2%, 3%, 4%, AND 5% INTERFERENCE AND RESIDUAL LEVELS AFTER COLD WORKING - PLANE STRAIN.

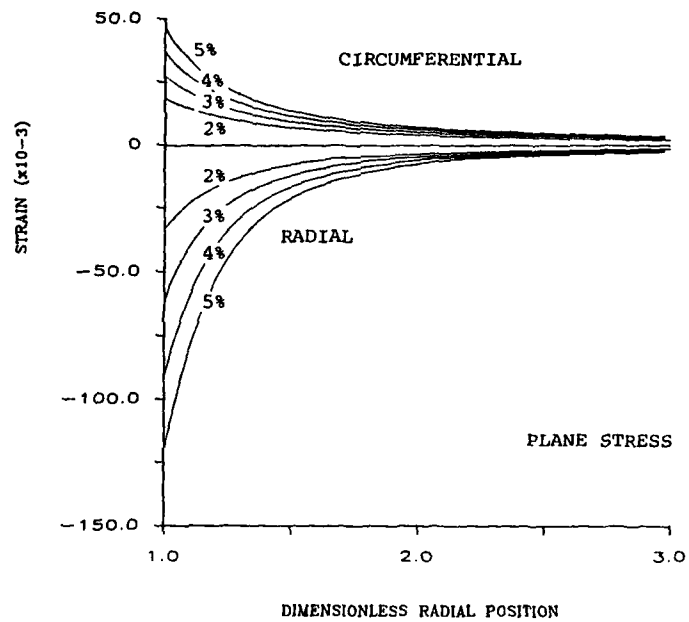


Fig. 6(a)

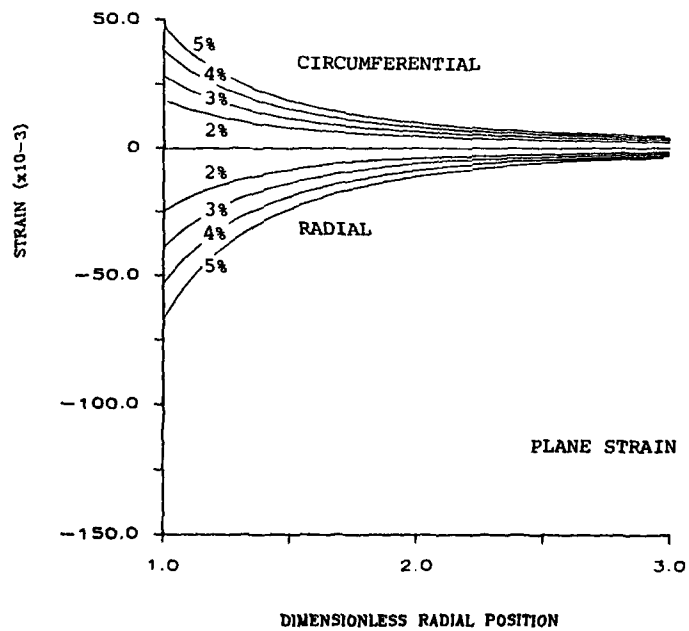


Fig. 6(b)

FIG. 6(a) & (b) CIRCUMFERENTIAL AND RADIAL STRAINS IN PLATE AT 2%, 3%, 4%, AND 5% INTERFERENCE.

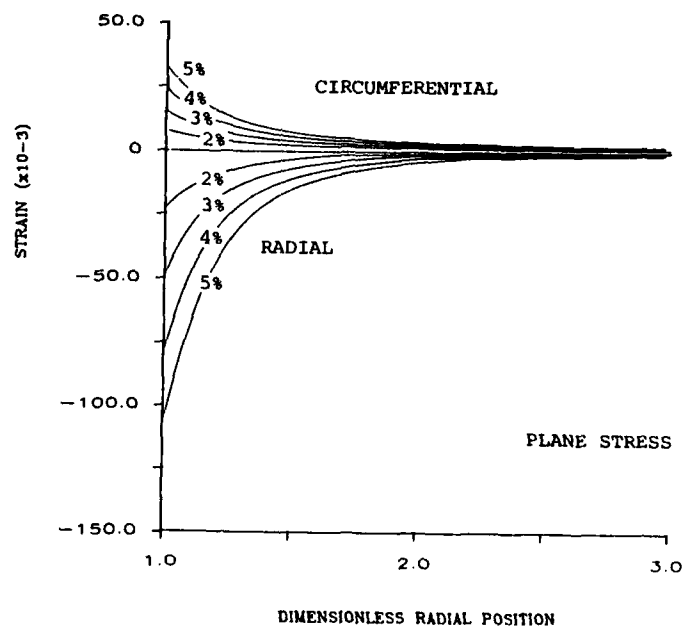


Fig. 7(a)

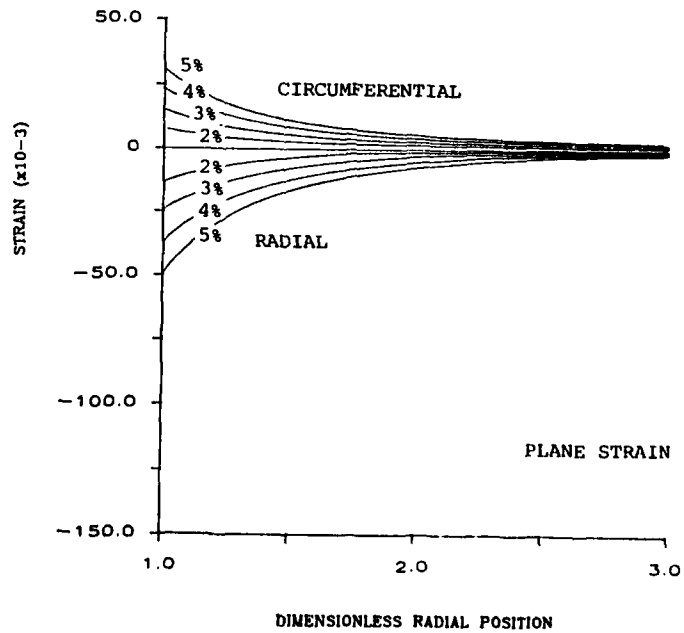


Fig. 7(b)

FIG. 7(a) & (b). RESIDUAL CIRCUMFERENTIAL & RADIAL STRAINS IN PLATE AT 2%, 3%, 4% AND 5% AFTER COLD-WORKING

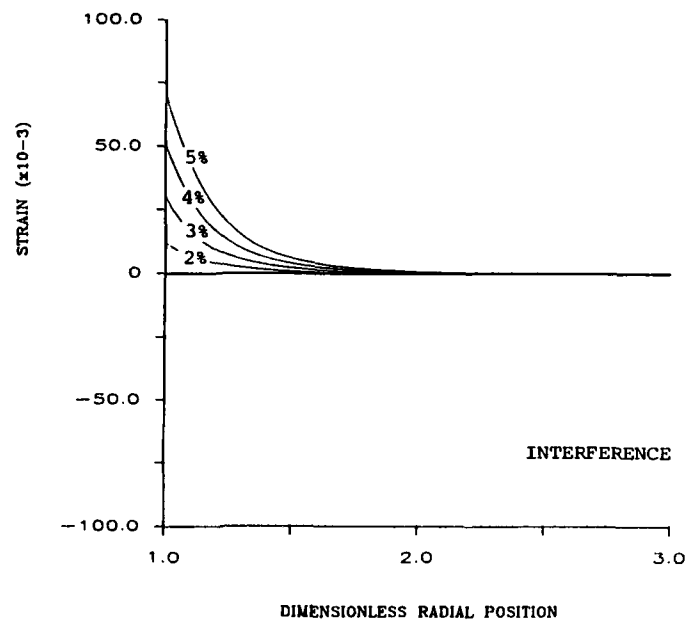


FIG. 8 (a)

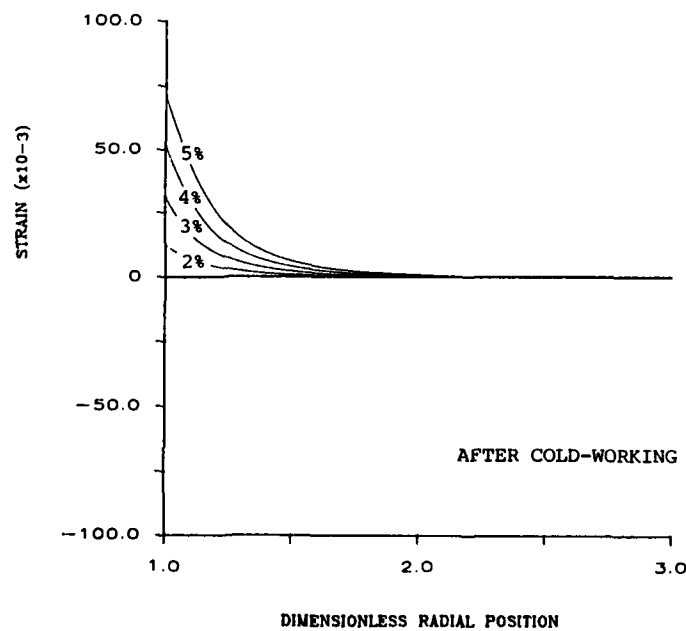


FIG. 8 (b)

FIG. 8 (a) & (b). OUT-OF-PLANE STRAINS IN PLATE AT 2%, 3%, 4% AND 5% INTERFERENCE AND RESIDUAL LEVELS AFTER COLD-WORKING - PLANE STRESS

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